Rapid Development of Aerodynamic Models for UCAV Flight Dynamics & Control Studies

Dr Doug Greenwell

Department of Aerospace Engineering
University of Bristol

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See also ADM001685, CSP 02-5078, Proceedings for Aerodynamic Issues of Unmanned Air Vehicles (UAV)., The original document contains color images.

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Are we getting the most out of the UCAV concept?

- unmanned = loss of flexibility
  - mission planning – restricted operational areas & times
  - autonomy – dealing with the unexpected!
- so what are the advantages?
  - cost
  - expendability – D^3 missions
- but are these being achieved?
- UCAVs still designed as '*unmanned manned aircraft*'
  - large, complex & expensive
  - long development times & protracted in-service life
  - definitely *not* expendable!

Instead, design for short service life …

- accept the inevitability of high attrition rate in service
  - ‘wooden round’ concept unworkable
  - launch & recovery accidents etc
  - operating in harms way
- design for short term flexibility
  - high-cost systems transported in low-cost airframe
  - modular ‘plug & play’ architecture – not integrated!
- plan for long term flexibility
  - rapid response to changes in concepts of use
  - take advantage of advances in airframe technology
- design for expendability
  - cost, numbers, replacement time
  - operators *must* be prepared to lose platforms

How are we going to do this?

- key factors
  - cost – development & manufacture
  - development time
  - platform flexibility
- look for common element …

  → the flight control system
  - *design*
  - *development*
  - *clearance*
- what's the problem with current FCS design process?
  - linear process
  - protracted & costly!

Conventional linear FCS design process

- FCS designed & implemented before 1st flight
  - complex, highly integrated systems
  - financial & political implications of accidents in flight test
- FCS design largely simulation based
  - therefore needs high quality aerodynamic S&C model
- extensive platform characterisation required
  - 1000's of hours of wind tunnel testing
  - specialist test facility needs for S&C
- *but* FCS problems still common in early flight test
  - F-16, F-22, Gripen, Dark Star etc …
- FCS development & clearance now the major element of a flight test programme

An alternative approach?

- do we really need a high level of integration?
  - are performance benefits worthwhile for low-cost UCAV?
- multiple losses in flight test acceptable for UCAVs
  - basic airframes are cheap, electronics are robust
- opportunities offered by modern FCS design tools
  - Nonlinear Dynamic Inversion (NDI)
  - *full (or accurate!) aero model not required for basic control*

  coupled with availability of
  - low-cost, high-performance computing hardware
  - improved data analysis techniques
  - low-cost, rapid airframe manufacturing methods
  - COTS airframe components

Iterative UCAV FCS development

- combine
  - aerodynamic characterisation
  - FCS design & development
  - platform optimisation
  - flight test

  in a single integrated, *iterative* process
- aerodynamic model and flight control laws developed in *parallel*
  - NDI (or similar) coupled with advanced non-linear parameter ID
  - recast aero model in control system form – eg aerodynamic transfer function
- final aero model ‘only as good as it needs to be’

A possible iterative UCAV design process

Concurrent Flight Testing

Concept Studies

Characterisation & FCS Design for Unpowered Model

Characterisation & FCS Design for Powered Model

Limited Flight Testing

Final FCS Design

Final Envelope Clearance

Limited Tunnel Testing

Design Freeze

First Flight

Aspects of an iterative approach

- use industry-standard control system design tools
  - PC-based FCS – maximum use of COTS components
  - desktop design & development environment
  - VAAC Harrier demonstrates potential of this approach
- an alternative 2-stage approach to clearance
  - control system architecture ***validated*** at sub-scale
  - ***verification*** of final (auto-coded) implementation
- flexible development process
  - technology insertion opportunities
- continuous risk reduction exercise
- shorter timescales & reduced cost
- ‘fit for purpose’ FCS